Anchovy (*Engraulis encrasicolus*) otoliths reveal growth differences between two areas of the Spanish Mediterranean Sea

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INTRODUCTION

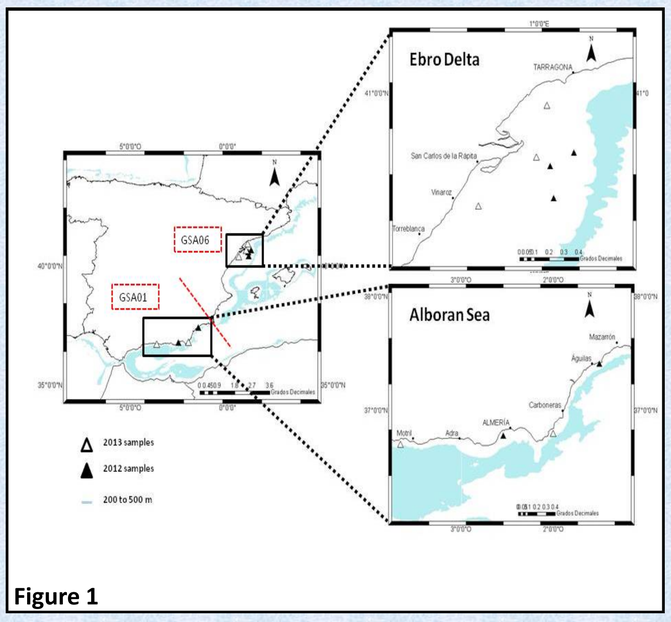


Figure 1

Small pelagics, as anchovy, support large fisheries in the Mediterranean Sea.
The General Fisheries Commission for the Mediterranean (GFCM) established 30 geographic areas of management (GSAs) including the Mediterranean and Black Sea. By means of acoustic surveys, spawning stock biomass of anchovy in the GSA06 (Balearic Sea) and GSA01 (Alborán Sea) subareas is determined annually (Fig. 1).

Biological small pelagic strategy is based on the existence of few year classes, in the Spanish Mediterranean case only three age classes are found (0, 1 and 2).
In the peak spawning (June –July), the most abundant age is 1 year old.
Otoliths are one of the most reliable tools for determining the age of a fish, so they are a powerful instrument in fisheries management and ecological studies.
The aim of this paper is to present the differences in anchovy growth found, for the same age, in two areas of high productivity of the Spanish Mediterranean (Alborán Sea and Ebro Delta) using as indicator the first otolith radius (R1).


Figure 2

MATERIAL

During MEDIAS_2012 and MEDIAS_2013 acoustic surveys conducted in June/July in the Spanish Mediterranean Sea, on board the *R/V Cornide de Saavedra*, opportunistic catches (Fig. 2 & 3) were performed for identifying echotraces and knowing the main biological variables of the target species (total length to the lower mm., wet weight in g., sex and maturity). Anchovy parameters are summarized in Table 1. *Sagitta* otoliths were removed (Fig. 4), mounted on a blackened black-ground and covered with resin (Eukitt).

In addition, salinity, temperature and fluorescence profiles were recorded using a CTD Seabird19+ (Fig. 5), and the mean values were computed.

	Alborán Sea	Ebro Delta	Total
Pelagic hauls	4	6	10
CTD samples	7	8	15
TL range (cm)	11 – 17	8 - 13	
W range (g)	10.8 – 40.0	3.0 – 15.0	
TL mean	14.86	10.97	
W mean	23.81	8.31	
Number	109	105	214
males	43	49	92
females	66	50	116
indeterminate	0	6	6

Table 1


Figure 3


Figure 4

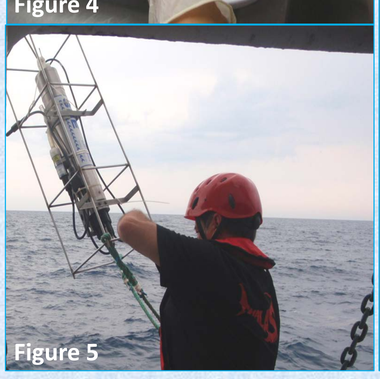


Figure 5

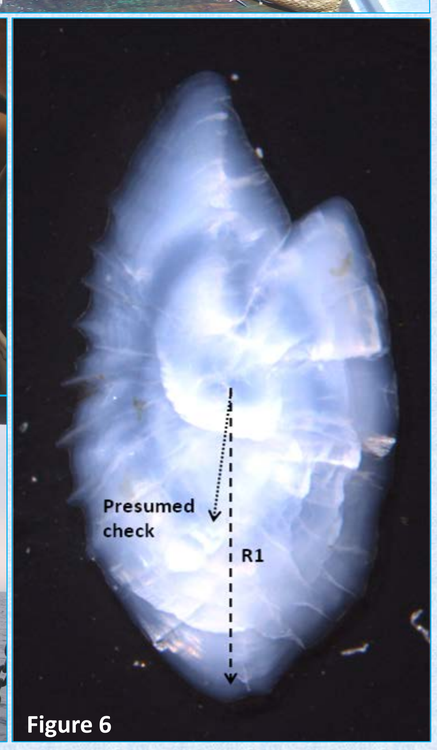


Figure 6

METHODS

Distance in microns between the core (the initial complex structure of an otolith) and the inner edge of the hyaline rings (R1) was measured using a digital image processing program (Motic images plus 2.0). Following ICES WKMIAS 2013, radii smaller than 850 µm (± 100µm) microns were assumed to be checks (Fig. 6).

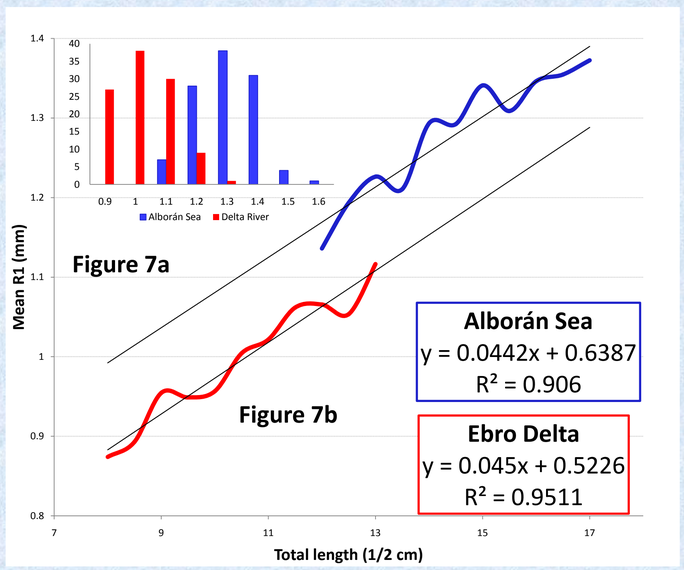
The relationship between R1 and total length was examined by regression analysis (Fig. 7b). Wilcoxon-Mann Whitney test was applied to detect significant differences between the median R1 in the two selected areas (Fig. 7a).

Similarities among specimens biological variables (size, weight, sex and maturity) were analyzed through Non-metric Multi-Dimensional Scaling (MDS) procedure and the dendrogram resulting from a group average, using Bray-Curtis distance, was superimposed (Fig 8). Also an analysis of principal components (PCA) was performed.

The relative condition factor was computed by sexes as $W_{rm} = 100 * W/a_m L^{bm}$.

Through the Welch test the hypothesis of equal means for the physical-chemical variables was contrasted.

RESULTS



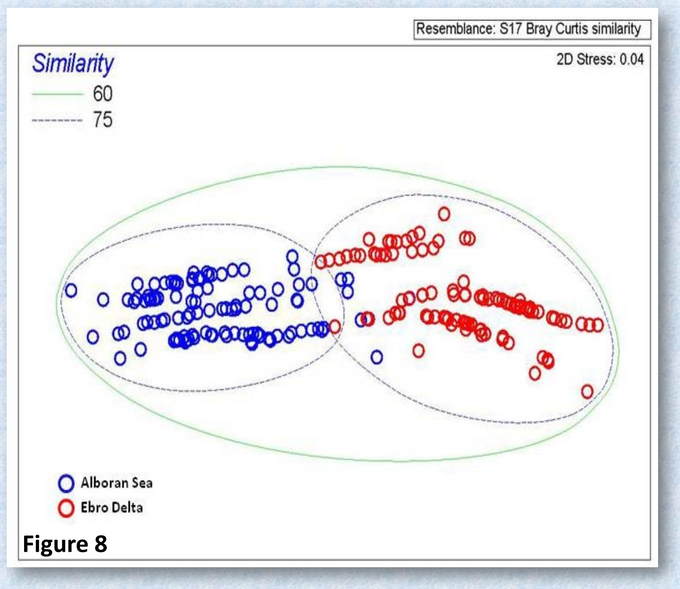


Figure 8

Mean R1 frequency distribution in Alborán Sea is shifted toward higher values compared to Ebro Delta area (Fig. 7a), Wilcoxon-Mann Whitney test confirmed significant differences between median radii (α=0.05). Regression analysis results highlighted that the best fit occurs when two different sets were considered, one per each area ($p<0.05$) (Fig. 7b).

Similarity analysis showed that the Spanish Mediterranean anchovies were divided into two different groups (similarity of 72%) as a result of their origin (Fig. 8). The main variables detected by PCA were weight and maturity.

The relative condition factor (W_{rm}) was 83.66 for the individuals analyzed in Alborán Sea (85.9♀ and 81.42♂) and 79.18 for the individuals in Ebro Delta (79.46♀ and 78.89♂).

The average salinity recorded was 37.36 ppm in the Alborán Sea and 38.02 ppm in Ebro Delta, average fluorescence was: 0.51 mg/m^3 and 0.39 mg/m^3 and temperature was 17.16°C and 17.09°C, respectively.

Welch test reveals significant differences between average salinities (α=0.05), being higher in Ebro Delta, and average fluorescence (α=0.05), being higher in Alborán Sea. There isn´t significant differences between average temperatures (α=0.05).

CONCLUSIONS

Anchovies in Alborán Sea seem to grow faster until form the first hyaline ring, assuming that false rings are formed at a distance from the nucleus of less than 850 µm, as in other areas.

In both areas females exhibit better relative condition than males, although both, males and females, have a better relatively condition in Alborán Sea, it could be consequence of more favorable environmental conditions.

Differences between R1, as an indicator of population growth within a population, can be attributed to different growth patterns which could be an effective tool in fisheries management due to its ability to highlight differences between population units.

Although the GFCM has established thirty management geographical sub-areas based on political considerations rather than biological factors, the present study provide biological evidences that GSA01 and GSA06 should be maintained as two individualized areas for anchovy assessment and management purposes in the Spanish Mediterranean Sea.

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